GROWTH AND FOOD HABITS OF SUPPLEMENTALLY FED AND UNFED YOUNG-OF-THE-YEAR CHANNEL CATFISH (*ICTALURUS PUNCTATUS*) HELD IN TWO PLASTIC-LINED PONDS

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INTRODUCTION

The commercial production of channel catfish (*Ictalurus punctatus*) is of growing economic interest. In addition, a growing human population and the increase in leisure time are producing a demand for sports fishing. The channel catfish filled the sports and commercial fisheries requirements admirably (Tiemeier, 1957). This demand emphasized the need for improved methods of producing fingerling channel catfish (Swingle, 1959; Prather, 1960).

The techniques for obtaining spawn from channel catfish and hatching the fry from this spawn were established at the Kansas Forestry, Fish and Game Commission hatchery at Pratt in the 1920's (Doze, 1925; Clapp, 1929). The feeding and growth of channel catfish fry became important once the problem of hatching the fry had been solved. Supplemental food in the diet of channel catfish fry has been studied for several years by investigators, but success has been limited and many facts on the dietary requirements of channel catfish fry need to be determined (Tiemeier and Deyoe, 1968).

The feeding habits of the channel catfish fry in an environment such as a rearing pond were of interest because it was thought naturally occurring food might play an important role in the diet. A greater understanding of this aspect of the nutrition of the fry could lead to better growth, more economical production, or both. The growth of the catfish during the first season was of paramount importance, because larger fingerlings mean shorter time to market size and higher survival of fish (Tiemeier, 1962).

If naturally occurring organisms can supply part or all of the food for channel catfish fry, a knowledge of the type of food consumed is important. It has been shown that channel catfish over 12 to 15 inches long utilize fish as food either partially or primarily and also consume benthic organisms (Swingle, 1954; Stevens, 1960; Busbee, 1968). Smaller individuals appear not be be piscivorous, but rely heavily on benthos as food.

Cook (1961) in a laboratory study involving the catfish *Corydoras aeneus* demonstrated a preference for live bottom organisms. Chironomids, ostracods, and cladocerans were preferred by juvenile and adult fish when placed in aquaria with these and other organisms. An almost exclusive preference for benthic organisms, especially chironomids, was shown by Minckley (1962) in stomach samples from young blue catfish (*Ictalurus furcatus*) ranging in length from 4.3 to 7.0 inches. A dependence on insects for food in channel catfish was noticed by Perry (1969) in individuals up to 376 mm long. These fish fed primarily on algae, insects, amphipods, and undetermined organic matter. When working with even smaller fish, Darnell (1958) found benthic organisms were also important in the diet of channel catfish 76 to 119 mm. long. Lagler (1956) stated initial food of most fish was plankton, small bottom animals, and periphyton.

If young channel catfish are omnivorous, a method of enhancing the planktonic and benthic communities should be beneficial to the fish. Bennett (1962) stated that correct fertilization of a pond enhanced fish production by increasing primary producers and consequently increasing consumers up to the fish. This trophic level increase resulting from fertilization was noticed by Ball (1949b) in a study of 21 ponds located at three Michigan fish hatcheries. Addition of 10-6-4 (N-P_2O_5-K_2O) fertilizer to the water produced noticeably larger populations of plankton and bottom invertebrates, especially chironomids, but increased fish growth much less dramatically than the planktonic and benthic communities. He suggested fish that feed on the lower trophic levels were more likely to be benefitted than fish higher on the food chain. The addition of urea (nitrogen) and superphosphate (phosphorus) to pond water by McIntire and Bond (1962) also increased the benthic and planktonic communities, particularly Bosmina, rotifers, and larval Tendipedidae. Midge larvae seemed to increase rapidly in water less than five feet deep. Fertilization in general, and phosphorous fertilization specifically, had the advantage of producing not only a good initial bloom, but also provided a continuous fertilization effect by releasing small amounts from the precipitate over a long period of time (Bennett, 1962; Simco and Cross, 1966).

The ability of fertilization to increase planktonic and benthic growth, combined with the possible utilization of these organisms as a food source for channel catfish fry provided the basis for this study. The experiment was designed to determine when supplemental feed was first ingested by the fry, and to compare growth and food habits of fry held in two plastic-lined ponds. One pond was fertilized at the beginning of the experiment to increase production of natural food organisms and the fry were not supplementally fed until late in the study. The other pond received supplemental feed daily but was not fertilized.

DESCRIPTION OF THE STUDY AREA

Ponds used in this experiment were located near Manhattan, Kansas in Pottawatomie County 0.5 miles south of Tuttle Creek Reservoir. Every effort was made to keep the ponds as similar as possible during construction. Both ponds were rectangular in shape with an area of 0.1436 surface acres each, and ranged in depth from 0.75 m. at one end to 1.37 m. at the other. Black polyethylene was used to line the ponds to prevent soil differences from influencing the results and to prevent seepage.

Water for filling the ponds was pumped from the Tuttle Creek river pond through a central pipe which bifurcated to valved inlets on one end of the ponds. The ponds sloped down from the inlet end to the outlet end where a drain was located. These drains and inlet valves allowed the water level in the ponds to be individually controlled. As the water entered the ponds, it was filtered through a fine mesh saran sleeve which removed the larger organisms.

MATERIALS AND METHODS

On June 18, 1968, 312 grams of channel catfish fry which had been spawned June 12 were obtained from the Kansas Forestry, Fish and Game Commission hatchery at Pratt. On the afternoon of June 18, 156 grams of these fry were stocked in both Pond No. 5 and 6 at the Tuttle Creek Fisheries Research Laboratory. The experimental ponds had been previously drained and rinsed to remove any mud or organic matter, and were then left dry until immediately before stocking to prevent any predaceous aquatic insects from becoming established prior to stocking.

On June 19, Pond No. 5 was fertilized with 7 pounds of 0-46-0 (50 pounds per acre of 46% triple superphosphate). This procedure was repeated on June 26 and July 3, at which time it was estimated a sufficient bloom had been produced. After this initial bloom, additional artificial fertilization was not attempted because organic content of the water was high. It was feared oxygen depletion leading to a fish kill might result from decay of the additional organic matter produced if extra fertilization was initiated. This pond received no supplemental feed until 22 August when a feeding program identical to that for Pond No. 6 was commenced.

The feeding program for Pond No. 6 was also initiated on June 19. The supplemental feed used throughout the experiment was Z-13 B. It contained 35% protein, 2.9% fat, 6.5% fiber, 10.2% ash, 11.2% moisture, and 956 kcals/lb. of metabolizable energy as determined from feed analysis tables for poultry. This diet was fed twice daily at 7:00 a.m. and 3:00 p.m. in a finely ground form which was assumed to be small enough to be utilized by the fry. The feed was presented at 5% per day of the estimated weight of 4,000 fry. The amount of feed given the fish was revised every two weeks on the same basis. On 10 August a commercial floating pellet was added to the Z-13 B diet on a basis of 100 grams per day. This pellet contained 25% protein, 2.1% fat, 7% fiber, 9.1% ash, 9.5% moisture, and 850 kcals/lb. of metabolizable energy. Together, the floating pellets and the Z-13 B continued to be presented at 5% every day of the estimated total body weight of the fry.

Sampling Techniques

Samples of plankton, benthos, and fry were taken twice weekly from each pond at 9:00 a.m. beginning Tuesday June 21 and continuing each Tuesday and Friday thereafter until 27 August. After this date, a weekly schedule was initiated starting 5 September and continuing until 19 September. The experiment was terminated on 28 September and the fish were removed, counted and the average weight estimated by weighing a sample of 200 fish in 20 groups of 10.

On every sampling date, except the terminal one, 25 fish were removed at random from each pond. These 25 fish were weighed as a unit to the nearest hundredth gram, and preserved in 10% formalin. Later the fish were measured individually for total length and the stomachs removed under a dissecting microscope. The stomachs were then emptied and the contents transferred with an eye dropper and stored in 10% formalin. No attempt was made to analyze individually the contents of each stomach, but all 25 specimens from one sample period were pooled. This procedure lost individual variance, but produced an averaging effect. The small size of the fry and the numbers involved made this technique necessary.

A plankton tow, bottom sample, and turbidity reading were also taken in each pond on each sampling date except September 28. These were always taken immediately prior to seining for fish because the seine disturbed the bottom materials and might have influenced other results.

Plankton were collected with a net made of No. 20 (0.076 mm.) mesh nylon bolting cloth. The net was 1.10 m. long and had an inside hoop diameter of 0.33 m. The cod end of the net had the screw cap from a #503 pint mason jar held in place by a hose clamp. This arrangement allowed the sampling jars to be attached directly to the plankton net and avoided the necessity of transferring the contents. This net was attached with nylon cords to the end of a 1.3 m. rod to prevent turbulence created by the operator from affecting the results. The pint jar was then removed from the net and the contents preserved in 10% formalin.

The polyethylene lining of the ponds made it impractical to use a dredge or other form of sampling device which might tear the liner. The device used for bottom samples was a plastic cylinder with an area of .00607 m^2. This cylinder was pressed into the mud on the bottom and a plastic disc slipped between the cylinder and the polyethylene. Contents of this sample were placed in a mason jar containing 10% formalin.

Turbidity was measured with a Hellige platinum-wire turbidimeter calibrated to read in parts per million. Readings were taken at the mid-point of each pond. When necessary, conditions such as rain or high wind were recorded if it was considered readings were affected by them.

Temperature data were collected in Pond No. 1 at the surface and a depth of 3.5 feet at 7 a.m. and 3 p.m. This schedule was maintained until September when the temperature was taken at 8 a.m. and 3 p.m. due to the change from daylight saving time to central standard. The data were assumed to be applicable to Ponds Nos. 5 and 6 because previous work had shown only slight variation in temperature (not more than 1° C) among ponds (Ewing, 1966).

Examination of Stomach Contents

Stomach contents were analyzed by placing them on a 9 cm. petri dish which had a grid of known area on the bottom. The contents were then classified and counted by means of a 10.5X to 45X variable power dissecting microscope. The stomach analyses from Ponds Nos. 5 and 6 for June 21 and Pond No. 5 for June 28 were total counts. All other counts were partial counts of 25%, 9.66% or 10.06% depending on the volume of the sample or the petri dish used. The partial counts were made by assigning numbers to the squares of the grid on the petri dish and by using random numbers selecting those squares to be counted. These squares were of a known area, and because the area of the petri dish was also known, the percent of the sample counted could be calculated. As the volume of the stomach contents increased, it became necessary to use more than one petri dish for each sample. Classification of the organisms present was made using keys in Ward and Whipple (1959) and Needham and Needham (1962). The organisms were identified to genera where feasible, but when impractical, classification was made as definite as possible.

After the organisms had been identified and counted, the sample was put in a 12 ml. graduated centrifuge tube and placed in an International Clinical Centrifuge. The sample was allowed to run for ten minutes at the No. 4 setting (1200 revolutions per minute). The volumes recorded from the sample were: total volume, chironomid volume, plankton volume, and, where applicable, supplemental feed volume. The volumes of chironomids often contained some feed and large invertebrates other than chironomids, and the plankton volume frequently contained some mucous. Volumetric readings were consistent, however, and considered relatively accurate.

Plankton Analysis

The concentrate from the plankton tow sample was first placed in a bucket and diluted to 10 l. A one ml. sample was then taken from this concentrate with a Hensen-Stempel pipette and placed in a Sedgewick-Rafter cell. The entire contents of this cell were then counted under a binocular microscope at 30 power. The organisms were identified using keys found in Ward and Whipple (1959), Needham and Needham (1962), and Smith (1950). Ten cells were counted and the average number of organisms per cell obtained. This figure was then multiplied by a conversion factor of 5.8459 to get the number of individuals per liter in the pond. This conversion factor was obtained by placing the number of milliliters of concentrate (10,000) over the number of liters of pond water sampled (1710.6).

Bottom Sample Analysis

Chironomids, snails, and other organic matter were separated from the mud with a #40 U. S. Standard sieve. The quality of the bottom matter was then noted, and the organisms placed in a 20 cm. x 30 cm. flat black tray. Individuals were then separated according to family and counted. Smaller individuals were separated and counted with a

15X dissecting microscope. Many organisms, especially bottom organisms, in the stomach samples were impossible to identify closely because they were mutilated or partially digested. Because of this difficulty with the stomach samples, it was considered impractical to identify closely the benthic organisms found in the bottom samples. A high degree of accuracy in identification of the bottom organisms would be wasted if the same amount of accuracy were not possible in the stomach samples.

DATA

EXPLANATION OF FIGURE 1

Changes in mean weight of samples of 25 channel catfish fry in fertilized Pond No. 5 and unfertilized Pond No. 6 plotted by dates of samples.

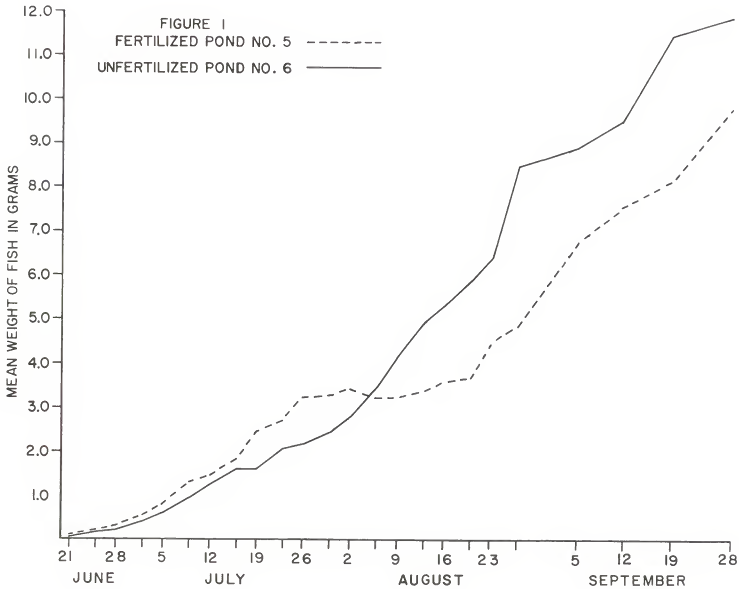
FERTILIZED POND NO. 5
UNFERTILIZED POND NO. 6
MEAN WEIGHT OF FISH IN GRAMS
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
21
28
5
12
19
26
2
9
16
23
5
12
19
28
JUNE
JULY
AUGUST
SEPTEMBER

FIGURE I

Table 1. Mean weight in grams of channel catfish fry taken from fertilized Pond No. 5 and unfertilized but fed Pond No. 6 on 24 sampling dates.

Sampling date	Mean weight in grams	
	Pond No. 5	Pond No. 6
21 June	0.08	0.07
25 June	0.20	0.16
28 June	0.29	0.20
2 July	0.55	0.40
5 July	0.79	0.60
9 July	1.29	0.94 (1)
12 July	1.47	1.25
16 July	1.85	1.61
19 July	2.44	1.60
23 July	2.77	2.07
26 July	3.25	2.17
30 July	3.30	2.47
2 August	3.43	2.80
6 August	3.26	3.49
9 August	3.24	4.17
13 August	3.40	4.88
16 August	3.61	5.32
20 August	3.68	5.92
23 August	4.44 (2)	6.39
27 August	4.87	8.49
5 September	6.79	8.90
12 September	7.54	9.52
19 September	8.16	11.46
28 September (3)	9.79	11.86

(1) First evidence of supplemental feed in stomachs of fish from Pond No. 6.

(2) Began supplemental feeding in Pond No. 5, 22 August, 12 a.m. First evidence of feed in stomachs, 23 August, 7 a.m.

(3) Weight upon removal of fish based on 200, all others on 25.

Table 2. Two-way analysis of variance table for the weight of channel catfish fry taken from Ponds Nos. 5 and 6 on 23 sampling dates.

Source of variance	Degrees of freedom	Sums of squares	Mean squares	F Statistic
Ponds	1	2721.953	2721.953	4.524*
Time	22	210973.834	9589.720	15.940*
Error	22	13235.742	601.625	
Total	45	226931.529		

* Indicates significance at .05 level.

EXPLANATION OF FIGURE 2

Changes in mean length of samples of 25 channel catfish fry in fertilized Pond No. 5 and unfertilized Pond No. 6 plotted by dates of samples.

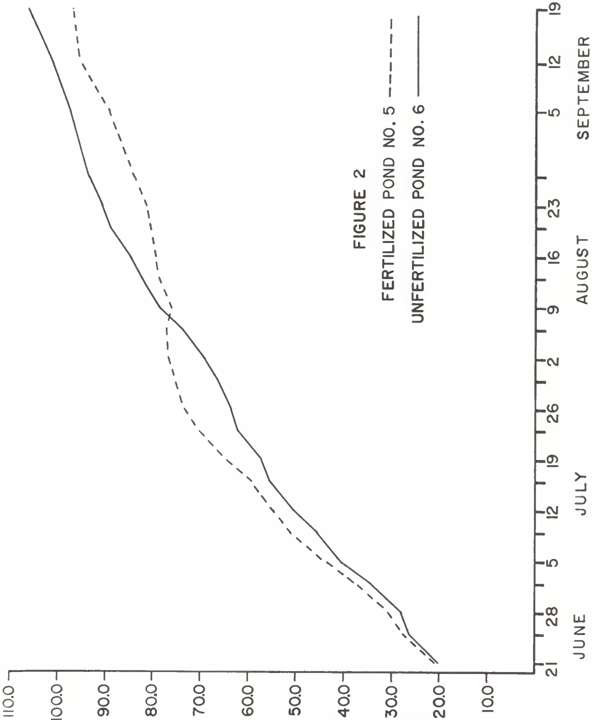
FERTILIZED POND NO. 5
UNFERTILIZED POND NO. 6
MEAN LENGTH OF FISH IN MILLIMETERS
110.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
21
28
5
12
19
26
2
9
16
23
5
12
19
JUNE
JULY
AUGUST
SEPTEMBER

FIGURE 2

Table 3. Mean length in millimeters of channel catfish fry stocked in fertilized Pond No. 5 and unfertilized but fed Pond No. 6 on 23 sampling dates. All lengths based on samples of 25 fish.

Sampling date	Mean length in millimeters	
	Pond No. 5	Pond No. 6
21 June	20.98	20.20
25 June	27.62	26.32
28 June	30.86	28.06
2 July	37.94	34.72
5 July	44.02	40.71
9 July	51.23	45.82 (1)
12 July	55.27	50.78
16 July	59.47	55.87
19 July	64.57	57.18
23 July	70.52	62.36
26 July	73.86	63.88
30 July	75.66	66.44
2 August	77.07	69.23
6 August	77.62	74.08
9 August	76.10	78.71
13 August	78.94	82.57
16 August	79.39	84.83
20 August	80.62	89.11
23 August	81.81	90.43 (2)
27 August	83.99	93.82
5 September	89.26	97.67
12 September	95.19	101.06
19 September	96.56	106.23

(1) First evidence of supplemental feed in stomachs of fish from Pond No. 6.

(2) Began supplemental feeding of Pond No. 5, 22 August, 12 a.m. First evidence of supplemental feed in stomachs, 23 August, 7 a.m.

Table 4. Two-way analysis of variance table for the length of channel catfish fry taken from Ponds Nos. 5 and 6 on 23 sampling dates.

Source of variance	Degrees of freedom	Sums of squares	Mean squares	F Statistic
Ponds	1	38.971	38.971	2.719
Time	22	602059.761	27366.353	1909.603*
Ponds x Time	22	12025.581	546.617	38.143*
Error	1104	15821.321	14.331	
Total	1149	629945.633		

* Indicates significance at .05 level.

Table 5. Volumes of stomach contents in fish taken from fertilized Pond No. 5 on 13 sampling dates.

Date	Total Vol. (ml.)	Plankton Vol.		Chironomid Vol. (1)		Feed Vol.	
		ml.	%	ml.	%	ml.	%
21 June	0.17	--	--	0.17	100	--	--
28 June	0.43	--	--	0.43	100	--	--
5 July	0.72	--	--	0.72	100	--	--
12 July	1.22	0.17	14	1.05	86	--	--
19 July	2.10	0.19	9	1.91	91	--	--
26 July	0.55	0.17	30	0.38	70	--	--
2 August	1.09 (2)	0.20	18	0.58	53	--	--
9 August	1.27	0.07	6	1.20	94	--	--
16 August	1.17	0.08	7	1.09	93	--	--
23 August	8.51	0.07	1	0.80	9	7.64	90
5 September	9.50	0.03	--	0.07	1	9.40	99
12 September	6.22	0.04	1	0.30	5	5.88	94
19 September	5.65	0.03	1	0.35	6	5.27	93

(1) Primarily chironomids, also contains gastropods and other insects.

(2) Included in this sample was an oligochaete with a volume of 0.31 ml., or 29% of the total volume.

Table 6. Volumes of stomach contents in fish taken from unfertilized but fed Pond No. 6 on 13 sampling dates.

Date	Total Vol. (ml.)	Plankton Vol.		Chironomid Vol. (1)		Feed Vol.	
		ml.	%	ml.	%	ml.	%
21 June	0.20	T	--	0.20	100	--	--
28 June	0.18	0.04	22	0.14	78	--	--
5 July	0.33	0.18	55	0.15	45	--	--
12 July	1.18	0.09	8	0.11	9	0.98	83
19 July	1.27	0.15	12	0.08	6	1.04	82
26 July	3.32	0.07	2	0.05	2	3.20	96
2 August	1.51	0.10	7	0.31	20	1.10	73
9 August	3.69	0.08	2	0.03	1	3.58	97
16 August	4.30	0.62	14	0.04	1	3.64	85
23 August	8.74	0.08	1	0.08	1	8.58	98
5 September	9.98	0.07	1	0.02	--	9.89	99
12 September	7.99	0.54	7	0.10	1	7.35	92
19 September	11.18	0.66	6	0.10	1	10.42	93

(1) Primarily chironomids, also contains gastropods and other insects.

Table 7. Two-way analysis of variance table for volumes of stomach contents in fish taken from fertilized Pond No. 5 and fed but unfertilized Pond No. 6 on 13 sampling dates.

Source of variance	Degrees of freedom	Sums of squares	Mean squares	F Statistic
Ponds	1	8.968	8.968	5.3185
Time	12	299.724	24.977	14.812*
Error	12	20.235	1.686	
Total	25	328.927		

* Indicates significance at 0.5 level.

Table 8. Most frequent items in stomachs of channel catfish fry from fertilized Pond No. 5.(1)

Organism	21 June	28 June	5 July	12 July	19 July	26 July	2 Aug.	9 Aug.	16 Aug.	23 Aug.	5 Sept.	12 Sept.	19 Sept.
Chironomid larva	30	89	240	684	942	248	412	662	374	669	52	216	233
Chironomid pupa	18	32	44	8	9	-	-	82	1	-	-	-	-
Bosmina	3	-	-	1324	2694	3072	3606	389	508	387	173	325	143
Alona	-	-	-	-	10	244	70	1621	840	388	142	215	173
Daphnia	1	1	40	296	249	108	-	112	20	10	41	-	30
Cyclops	5	-	4	28	62	172	20	71	536	61	-	62	52
Diaptomus	6	1	-	12	52	24	132	-	20	-	30	-	10
Ostracoda	-	2	-	12	10	32	-	104	92	41	40	92	31
Hemiptera	-	1	1	24	-	1	-	-	2	-	-	1	2
Culicoides larva	-	-	-	1	21	1	-	-	-	-	-	-	-
Gastropods	-	-	-	-	1	2	5	5	-	3	1	2	1

(1) Does not include supplemental food present from 23 August to termination.

Table 9. Most frequent items in stomachs of channel catfish fry from fed but not fertilized Pond No. 6.(1)

Organism	21 June	28 June	5 July	12 July	19 July	26 July	2 Aug.	9 Aug.	16 Aug.	23 Aug.	5 Sept.	12 Sept.	19 Sept.
Chironomid larva	33	79	308	244	200	92	184	71	91	173	50	223	234
Chironomid pupa	19	9	-	4	4	-	2	-	-	-	-	-	-
Bosmina	1	765	2124	364	144	364	583	263	1125	235	112	419	415
Alona	-	-	-	120	452	181	20	182	4443	133	173	2390	2357
Daphnia	-	16	80	56	24	51	10	10	61	20	41	-	10
Cyclops	1	-	16	20	8	-	30	20	-	10	31	31	102
Diaptomus	4	-	12	8	-	-	-	-	-	31	41	-	31
Ostracoda	2	31	8	4	-	-	-	-	375	51	31	122	273
Hemiptera	-	2	-	-	-	-	1	-	1	-	1	-	2
Gastropods	-	-	-	2	-	4	7	2	1	8	5	7	2

(1) Does not include supplemental food present from 12 July to termination.

EXPLANATION OF FIGURE 3

Changes in density of algae, rotifers, and crustaceans in fertilized Pond No. 5 plotted by dates of samples.

FIGURE 3

POND NO. 5 (FERTILIZED)

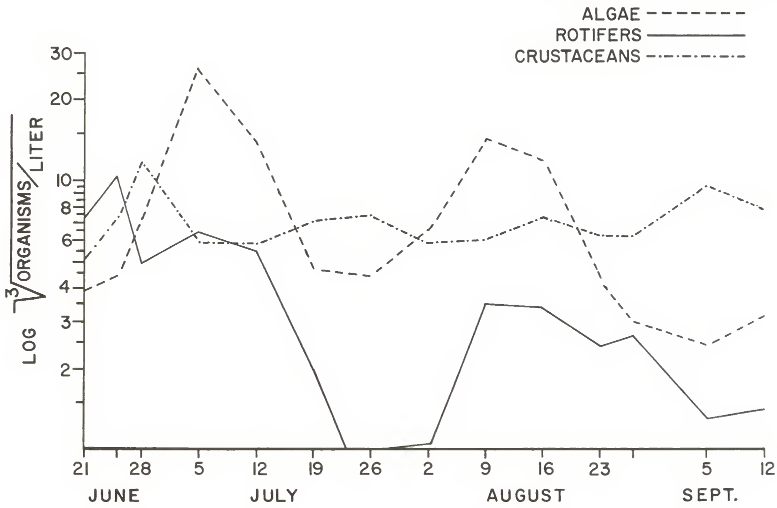

Table 10. Analyses of plankton tows from fertilized Pond No. 5. (All figures in individuals/liter)

Organism	21 June	25 June	28 June	5 July	12 July	19 July	26 July	2 Aug.	9 Aug.	16 Aug.	23 Aug.	27 Aug.	5 Sept.	12 Sept.
Crustacea	138.55	397.52	1544.52	201.11	198.17	356.60	406.29	205.79	218.05	395.78	242.62	240.86	890.94	486.96
Nauplius larva	68.98	282.36	1077.42	114.58	88.27	119.84	202.27	94.71	35.08	298.73	31.57	106.98	454.98	224.49
Cladocera	16.37	28.64	333.81	50.86	54.95	132.70	91.20	38.59	31.56	26.89	68.99	26.31	14.03	25.13
Daphnia	1.75	10.52	56.71	19.88	16.37	26.89	5.26	3.51	7.60	5.84	7.02	17.54	7.60	11.69
Bosmina	13.45	18.12	275.35	30.98	38.58	105.23	85.94	35.08	22.21	11.11	49.11	4.09	4.68	12.86
Alona	-	-	-	-	-	-	-	-	1.75	9.94	12.86	4.68	1.75	0.58
Copepoda	53.20	86.52	133.29	35.67	54.95	104.06	112.82	72.49	151.41	70.16	142.06	107.57	422.09	236.76
Cyclops	49.69	78.34	107.57	28.65	32.15	54.37	90.61	52.03	114.00	42.68	132.12	78.34	364.21	151.41
Olaptomus	3.51	8.18	25.72	7.02	22.80	49.69	22.21	20.46	37.41	27.48	9.94	29.23	57.88	85.35
Rotifera	377.66	1089.69	121.00	271.83	162.53	7.60	-	1.16	42.67	39.16	14.61	18.71	2.34	2.92
Brachionus	84.77	212.79	74.24	18.12	94.71	4.09	-	-	41.51	38.58	12.28	18.71	2.34	2.92
Conochilus	254.89	841.24	10.52	1.75	2.34	-	-	-	-	-	1.17	-	-	-
Keratella	14.62	10.52	25.72	251.38	65.48	3.51	-	-	0.58	0.58	0.58	-	-	-
Asplanchnia	2.92	3.51	1.75	-	-	-	-	0.58	0.58	-	0.58	-	-	-
Polyarthra	17.54	20.46	7.60	0.58	-	-	-	-	-	-	-	-	-	-
Hexarthra	2.92	-	1.17	-	-	-	-	-	-	-	-	-	-	-
Algae	59.04	87.69	391.67	18,180.48	2806.88	99.38	88.27	295.23	2963.34	1688.33	74.24	26.89	15.20	32.15
Pediastrum	57.88	34.49	59.04	291.72	15.78	77.17	67.81	3.51	21.63	17.54	24.55	26.89	15.20	32.15
Anabaena	0.58	52.03	332.05	17,888.76	2790.88	22.21	20.46	291.72	2940.54	1670.79	41.51	-	-	-
Melosira	-	-	-	305,511.96	-	-	-	-	-	-	-	-	-	-

EXPLANATION OF FIGURE 4

Changes in density of algae, rotifers, and crustaceans in unfertilized Pond No. 6 plotted by dates of samples.

FIGURE 4

POND NO. 6 (UNFERTILIZED)

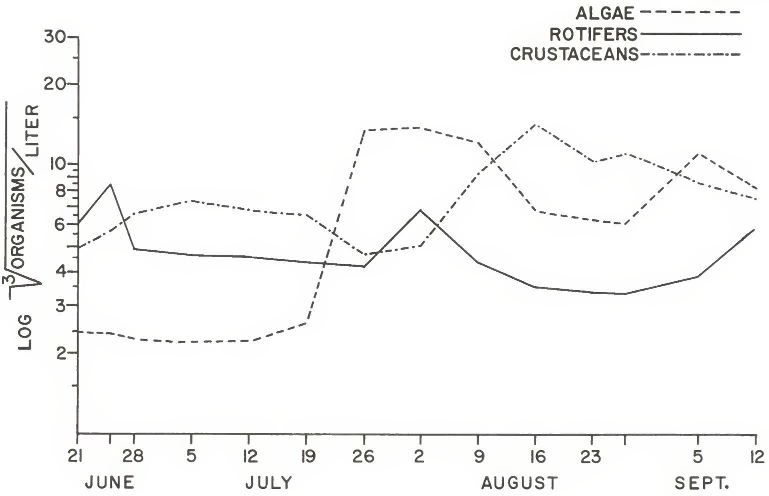

Table 11. Analyses of plankton tows from fed but not fertilized Pond No: 6. (All figures in individuals/liter)

Organism	21 June	25 June	28 June	5 July	12 July	19 July	26 July	2 Aug.	9 Aug.	16 Aug.	23 Aug.	27 Aug.	5 Sept.	12 Sept.
Crustacea	119.85	181.24	277.69	395.78	316.85	282.94	100.53	126.86	823.12	2783.20	1103.71	1354.52	647.15	436.69
Nauplius larva	45.60	101.16	181.23	191.75	132.12	119.84	30.40	19.88	167.78	594.54	271.83	199.35	133.87	101.72
Cladocera	30.99	31.56	59.05	167.20	127.44	135.63	52.60	92.95	617.34	1939.62	755.89	1034.74	446.05	287.62
Daphnia	4.68	2.92	2.34	12.28	27.48	69.57	9.35	6.43	9.35	23.38	9.94	7.60	8.77	5.26
Bosmina	26.31	28.06	56.71	154.92	98.21	55.54	40.92	83.60	598.05	1842.66	741.86	1021.88	434.94	279.44
Alona	-	-	-	-	-	-	0.58	1.75	9.94	70.74	2.92	2.34	-	1.75
Copepoda	43.26	48.52	37.41	36.83	57.29	27.47	17.53	14.03	38.00	249.04	75.99	120.43	67.23	47.35
Cyclops	35.08	40.34	30.98	18.71	45.01	18.12	16.95	11.69	33.91	235.59	70.15	114.00	62.55	42.09
Diaptomus	8.18	8.18	6.43	18.12	12.28	9.35	0.58	2.34	4.09	13.45	5.84	6.43	4.68	5.26
Rotifera	221.56	605.06	114.57	96.45	92.95	81.84	74.24	320.35	84.18	43.26	38.56	36.24	58.47	192.91
Brachionus	71.32	87.11	36.83	39.75	26.89	15.20	12.86	229.75	40.34	9.94	18.12	19.29	7.02	4.09
Conochilus	132.12	499.83	67.81	1.75	4.68	7.60	14.03	30.40	20.46	10.52	12.84	5.84	20.46	169.53
Keratella	1.17	2.92	2.92	34.49	45.60	58.46	46.77	54.95	21.05	18.17	7.02	11.11	17.54	18.12
Asplanchnia	-	-	0.58	0.58	0.58	0.58	-	1.75	0.58	4.09	0.58	-	13.45	1.17
Polyarthra	11.69	3.51	2.92	1.17	-	-	0.58	-	0.58	-	-	-	-	-
Hexarthra	3.51	11.69	3.51	18.71	15.20	-	-	0.58	-	-	-	-	-	-
Algae	14.03	13.44	11.68	10.52	11.11	17.53	2462.92	2523.71	1794.13	311.59	251.38	227.41	1388.43	568.82
Pediastrum	12.28	5.26	10.52	9.94	11.11	8.18	1.75	8.18	60.21	310.42	250.21	227.41	1388.43	568.82
Anabaena	1.75	8.18	0.58	0.58	-	9.35	2461.17	2513.78	1732.75	-	-	-	-	-

Table 12. Contents of bottom samples taken from Ponds Nos. 5 and 6. (All numbers in organisms/m^2.) (1)

Date	Chironomid larvae		Chironomid pupae		Gastropods	
	Pond #5	Pond #6	Pond #5	Pond #6	Pond #5	Pond #6
25 June	50,413	20,165	--	--	165	165
28 June	65,951	23,967	826	--	331	--
5 July	80,827	26,612	661	--	--	--
12 July	89,587	21,322	--	--	496	165
19 July	73,719	11,570	496	--	--	--
26 July	5,124	2,975	--	165	--	--
2 August	2,975	4,132	--	--	661	826
9 August	1,157	2,810	--	--	--	--
16 August	661	1,983	--	--	331	--
23 August	661	1,157	165	--	826	165
5 September	826	331	--	1,157	331	--
12 September	993	661	--	826	661	165

(1) # per sample x 165.3.

Table 13. Mean a.m. and p.m. temperatures taken near the surface and at 3.5 feet. (All temperatures in °F.)

Period	7 a.m. 0'	7 a.m. 3.5'	3 p.m. 0'	3 p.m. 3.5'	Mean
June 17 to 30	74.0	74.0	83.2	76.8	77.0
July 1 to 13	76.5	76.4	86.7	78.5	79.5
July 15 to 26	79.2	80.0	86.9	81.0	81.8
July 29 to August 9	79.2	79.3	84.0	81.7	81.1
August 12 to 23	78.6	78.6	85.6	83.0	81.5
August 26 to 30	72.8	73.0	77.0	74.4	74.3
	8 a.m.		3 p.m.		
September 2 to 6	68.8	68.8	75.0	72.0	71.2
September 9 to 13	66.6	66.8	75.6	71.4	70.1
September 16 to 20	65.2	64.8	71.2	67.6	67.2

Table 14. Turbidity of ponds in p.p.m. at sampling dates.

Date	#5 (Fertilized)	#6 (Fed)
19 June	23	10
21 June	21	10
24 June	35	14
26 June	55	18
28 June	45	12.5
2 July	45	22
5 July	55	26
9 July	55	38
12 July	75	45
16 July(1)	75	60
19 July	70	55
23 July	60	55
26 July(1)	60	35
30 July(1)	80	70
2 August	raining	raining
6 August	90	60
9 August	100	75
13 August	130	90
16 August	130	100
20 August	130	110
23 August	130	140
27 August	115	95
5 September	140	80
12 September	170	85
19 September	170	70

(1) Windy and raining the night before readings were taken.

Table 15. Production of channel catfish fry in fertilized Pond No. 5 and fed Pond No. 6.

Pond	Lbs. fish	Mean wt. (g)	No. fish	Lbs./acre	Fish/acre	No. harvested/ lb. fry stocked
5 (1)	82.3	9.79	4,426	572.8	30,805	12,881
6 (2)	109.0	11.86	4,785	758.6	33,304	13,926

(1) 609 fish removed during summer but data were not included in (lbs. fish), (mean wt.), or (lbs./acre).

(2) 611 fish removed during summer but data were not included in (lbs. fish), (mean wt.), or (lbs./acre).

RESULTS

Fry in Pond No. 5 gained more in weight (Fig. 1, Table 1) and length (Fig. 2, Table 3) initially than fry in Pond No. 6. This period of more rapid gain in weight continued until 26 July when rate of gain of the unfed fish slowed or ceased. The rate of gain in length of fry was also greater in Pond No. 5 until approximately 30 July, when gain in length also slowed. The average weight of fed-fry became greater than that of the unfed fry on 6 August, and by 9 August, length of fry in Pond No. 6 was greater than fry in Pond No. 5. The fed-fry appeared to have no sustained periods of slow growth or lack of growth as did fry in the fertilized pond.

Fish in Pond No. 5 showed a large gain in weight on 23 August in response to supplemental feeding initiated on 22 August at 12:00 a.m. Length also showed an increase on this date, although not as dramatic an increase as in weight. After 23 August, weight and length seemed to increase at the same rate in both ponds with the fed-fry remaining larger in both measurements.

As shown by the analysis of variance, the length of fry increased significantly over the period studied (Table 4). The pond-time interaction was also found to be significant at the .05 level which indicated a different rate of gain between Ponds Nos. 5 and 6 over the period the experiment was conducted. The analysis of variance of weight (Table 2) did not allow the estimation of interaction because fry from each sample were weighed as a group. The data did indicate, however, that the difference in weight of fish between the two ponds was significant, and the weight of the fry in the two ponds increased with time.

In both these analyses, there was a great difference in population variances of fish size ranging from 1.19 to 106.43 for length, and from 1.02 to 7006.19 for weight. The assumption for the analysis of variance that population variances were equal was found invalid when the Hartley maximum-F test was applied (Fryer, 1966). The wide range of variances would be expected, however, because of the great amount of growth exhibited by the fry.

Based on information gathered from the final seining on 28 September (Table 15), production in Pond No. 6 was greater not only in average weight of the fish, but also in total pounds of fish produced. The fed pond also had more total fish, pounds per acre, and fish per acre than the fertilized pond. Because the number of fish recovered was higher in Pond No. 6, and the same weight of fry was initially placed in each pond, the number of fry harvested per pound of fry stocked was also higher in the fed pond.

Supplemental feed was first found in the stomachs of fry in Pond No. 6 on 9 July. On this date of the 25 fry sampled, six contained feed and all six had distended bellies. Two of these six fry were estimated to contain less than 50% supplemental feed, and the other four were estimated to have over 80% supplemental feed in the stomach contents. Of the 25 fry examined from Pond No. 6 on the next sampling date, 12 July, only seven stomachs contained no feed. Centrifuging the stomach contents of all 25 fry examined from Pond No. 6 for this date showed 83% of the contents was supplemental feed (Table 6). On 16 July, or one week after feed was first detected in the stomachs, the fry in Pond No. 6 were observed to be actively taking feed on the surface when it was offered to them.

Prior to taking feed, the fry in Pond No. 6 relied heavily on the benthos as food. Initially, chironomid larvae were the primary food source with a shift toward zooplankton, especially *Bosmina* (Table 9), before taking supplemental feed. This was shown volumetrically in Table 6 as the chironomid quantity dropped from 100% to 45% in the three weeks prior to acceptance of the feed. The volume of chironomids never exceeded that of the zooplankton after this date except on 2 August. On this date, there was a heavy rain during the early morning and through most of the day. *Bosmina* and chironomid larvae were important components of the natural diet throughout the study (Table 9), but after the fry began taking supplemental feed, *Alona* and gastropods also became important in the diet.

The reliance on chironomids was more pronounced in Pond No. 5 than in Pond No. 6. The chironomid volume in stomach samples from fish in the fertilized pond was always greater than that of zooplankton (Table 5). The lowest volume of chironomids found in stomach samples from fish in Pond No. 5 prior to acceptance of supplemental feed was found on 2 August when rain apparently influenced the feeding habits of fry in both ponds.

The early predominance of chironomids in the diet of fry in Pond No. 5 was also shown in the stomach content analyses (Table 8). *Bosmina* became important in the diet by 12 July and rose in importance until 2 August and then declined. Alona and gastropods were also found more frequently later in the study.

Feed was first presented to the fry in Pond No. 5 on 22 August, and of the fish sampled on 23 August, 90% of the food in the stomachs was supplemental feed (Table 5). Total volume of the stomachs rose from 1.17 ml. on 16 August to 8.51 ml. on 23 August. On that date, of the fry sampled, only one had no supplemental feed in the stomach. The other 24 fish all had distinctly distended bellies from the feed consumed.

An analysis of variance on total stomach content volume (Table 7) showed no significant difference between the two ponds for the period studied. Because the stomach contents of all 25 fish in one sample were centrifuged at one time, no estimate was possible for interaction effect. The analysis did indicate, however, that the increase in total volume of stomach contents for Ponds Nos. 5 and 6 was highly significant for the time the experiment was conducted.

As was found in the length and weight analyses, a large difference in population variances was found in the volumes of stomach contents taken throughout the study. This difference (0.0005 to 15.8489) caused the Hartley maximum-F test to again invalidate the assumption that population variances were equal. An increase in variances was expected in the experiment because of growth of the fry and a consequent increase in stomach volume.

Aside from supplemental feed, the fry fed primarily on those organisms listed in Tables 8 and 9. On only one occasion (Pond No. 6, 19 August) was a large amount of algae found in the stomach of a fry.

With this exception, and with the exception of the small but consistently present amounts of detritus, the fry were almost totally carnivorous. In addition to the organisms listed in Table 8, the following organisms were found in the stomach samples of fry from Pond No. 5 on more than one occasion: Ceriodaphnia, Diaphanosoma, nauplius larvae, Formicidae, Trichoptera (Leptoceridae), Hydrophilidae, Gyrinidae, Odonata nymph, Chironomidae adult, and Oligochaeta. With the exception of the last three, all the above organisms plus Spyrogyra were also found in stomach samples from fish in Pond No. 6. None of these organisms were found in the stomach samples from either pond in other than small numbers. The most numerous were the nauplius larvae of which 24 were found in the stomach samples from Pond No. 5 on 28 June. Aside from this date, nauplius larvae were almost never present. In addition to the organisms mentioned, highly mutilated and therefore unidentifiable insect remains (both adult and immature stages) were occasionally found.

Results of plankton tows from Pond No. 5 (Table 10, Fig. 3) showed sharp initial increases in the zooplankton populations which peaked on 25 June (rotifers) and 28 June (crustaceans). Also found at the outset of the experiment in Pond No. 5 was an increase in the algae population which peaked on 5 July. Following the initial peak of 25 June, the rotifer population declined to zero on 26 July and then rose to a second peak on 9 August. Following the maximum density on 5 July, the algae population also dropped until 26 July, and then underwent a second bloom which peaked on 9 August. Following the initial peak, the crustacean population declined on 5 July, and then underwent a gradual increase in numbers for the remainder of the study.

Melosira reached bloom proportions in Pond No. 5 on 5 July (Table 10). This diatom was present previous to this date, but only in small numbers. Aside from Melosira, the primary bloom algae was Anabaena which was the primary factor in both the initial and second rise in algae population density (Table 10, Fig. 3). The increase in the rotifer population on 28 June consisted primarily of Conochilus, but Brachionus and Keratella were also important factors in the population throughout the study. Nauplius larvae contributed heavily to the crustacean population throughout the summer as did Bosmina and Cyclops to a lesser degree.

At the outset of the experiment, Pond No. 6 did not have an increase in the algae or crustacean populations (Table 11, Fig. 4) as did Pond No. 5. A rise in the rotifer population did occur on 25 June in Pond No. 6, but did not reach the proportions of the rotifer population in the fertilized pond which peaked on the same date. An algae bloom occurred on 26 July in Pond No. 6 (Table 11, Fig. 4) two weeks prior to the second bloom in Pond No. 5, but not as great in extent as either major bloom in the fertilized pond. The crustaceans appeared to maintain a stable population until 9 August, when a sharp increase occurred (Table 11, Fig. 4). This rise peaked on 16 August and began to drop gradually for the remainder of the study period. An increase in the algae and rotifer populations occurred late in the study with the high point for algae reached on 5 September and the rotifer peak being on 12 September. Neither the algae nor the rotifer population reached the previous densities in this late bloom.

As with Pond No. 5, the algae blooms in the unfertilized pond were primarily of Anabaena (Table 11, Fig. 4) and there was no dramatic bloom in Melosira as occurred in the fertilized pond. Conochilus was again the most important component of the rotifer population, but the Brachionus and Keratella populations were not as large as in Pond No. 5. Bosmina reached high densities late in the summer as did nauplius larvae and Cyclops and were the primary components of the bloom found on 16 August in the crustacean population.

Chironomid larva populations as shown in the bottom samples (Table 12) were much higher in the fertilized pond until 2 August. The number of midge larvae in Pond No. 5 peaked on 12 July and dropped sharply after 19 July. Pond No. 6 also had a sharp drop in chironomid larva numbers after 19 July, but the population peaked a week earlier than Pond No. 5. The midge population in the fertilized pond was lower than in the unfertilized pond after the drop from 9 August until 23 August when a slight rise started. Chironomid pupa and gastropod populations were erratic throughout the summer. Bottom samples showed a large amount of sand present in both ponds from 26 July to the last date samples were taken. Pond No. 5 had more sand initially, but the ponds seemed to be equal in this aspect by the end of August.

Turbidity (Table 14) increased in both ponds from the initiation of the study until 27 August when both declined. Turbidity in Pond No. 5 increased again after the drop on 27 August and continued to increase until the last sample was taken on 19 September. Pond No. 6, however, showed a continual decrease in turbidity from the high of 140 p.p.m. on 23 August until the termination of the experiment. The high for Pond No. 5 was 170 p.p.m. which occurred on both 12 September and 19 September.

DISCUSSION

Sampling methods used in this study assumed the organisms sampled were randomly distributed throughout the pond. The seining technique used to acquire fish samples may have selected for certain individuals despite the large numbers of fry obtained each time. Dr. O. W. Tiemeier (personal communication, 1969) found a slight tendency toward a biased selection of fish on a basis of size when seining ponds used in his studies. Realizing the possibility of a non-random selection of fish in the seining technique, it was assumed that if it occurred, it was constant, and therefore would not influence comparative growth data (Figs. 1 and 2, Tables 1 and 3).

The time the fry were sampled was also important. The study of stomach contents required a determination of when the fish had fed. It was thought that samples should be collected shortly after the fish fed in order that organisms in the stomachs not be severely affected by digestion. It was also thought that digestion of the most easily digested organisms would occur first and might influence the results unfavorably (Lagler, 1956). Because the fry were fed in the early morning, it was decided to take samples soon after this feeding.

Bailey and Harrison (1948) found the most active natural feeding time for larger channel catfish was from sundown to midnight. If this occurred in young channel catfish, the sampling time may have skewed results from the stomach samples in favor of the supplemental feed. Because the stomach samples did show some evidence of advanced digestion of the softer bodied organisms, such as chironomid larvae and gastropods, the possibility of this affecting the results, especially volumetrically, cannot be ignored.

Techniques used to take planktonic and benthic samples also assumed random distribution throughout the pond. Ragotzkie and Bryson (1953) showed plankters were highly influenced by wind currents and tended to aggregate according to these currents. The length of the plankton tow (almost half the length of the pond) and the small size of the pond enhanced the possibilities of obtaining representative samples (Figs. 3 and 4, Tables 10 and 11).

The pond bottoms slope toward the drain, and mud tends to collect in the deeper areas. It was impossible to take bottom samples in areas where the plastic liner had no overlying layer of mud, although chironomid larvae and other organisms were observed there. This difficulty in taking benthos samples where no mud had accumulated led to the technique used of collecting samples from the same location each time. The area chosen had a depth of approximately 3 inches of sediment present throughout the study. Because the areas of concentration of bottom matter stayed constant, it was decided this technique would allow more accurate analyses than if a different area were sampled on each sampling date. The possibility that the benthic organisms were patchy, and the samples taken in this localized area not numerically representative of the entire pond could not be ignored. Bottom samples (Table 12) were viewed as comparative samples rather than a comprehensive illustration of the total population.

The interaction of fish, supplemental and natural food, fertilization, and the physical environment were all involved in this study. Because of this interaction, caution was necessary in applying the results obtained in this study to a less artificial environment. Shell (1966) warned that when using artificial plastic-lined ponds in fertilization experiments, care should be taken in assuming results were comparable to those obtained in an earthen pond. The absence of a large variety of benthic organisms, both plant and animal, may have had an effect on the fish growth and food habits. The artificial lining may also have influenced the fertilization of Pond No. 5 in the availability of added nutrients to the primary producers, or the effect of the fertilizer on the organisms. The time the supplemental feed was utilized by the fish may also have been influenced. The absence of mud in large areas of the pond may have made the feed available earlier in larger quantities. The larger quantities available may have also influenced the amount of feed eaten by the fry.

The fry grew well in both ponds throughout the summer (Tables 1 and 3, Figs. 1 and 2) with the exception of the period from 26 July to 20 August in Pond No. 5. Because the fry in Pond No. 6 apparently did not take the supplemental feed offered them for the first three weeks, the initially more rapid growth of fry in the fertilized pond was not surprising. Investigators (Ball, 1949a, 1949b; Simco and Cross, 1966) have shown that fertilization enhances fish production in cases where supplemental feed was not utilized.

The initial increase in fish production in Pond No. 5 was apparently because fertilization increased primary production which resulted in greater numbers of food organisms (Forney, 1968). An increase in numbers of planktonic and benthic organisms after fertilization was observed by McIntire and Bond (1962) when they applied urea (nitrogen) and phosphate. The increase in numbers of organisms was shown in the initial rise in plankters (Figs. 1 and 2) and chironomid larvae (Table 12) in Pond No. 5 over Pond No. 6. Ball (1949a) showed that pond fertilization not only produced more organisms, but that important food organisms for fish were also increased. Analysis of the stomach contents of fry from both ponds (Tables 8 and 9) has shown the importance of midge larvae and crustaceans especially Bosmina, Alona, and Cyclops. These organisms were all generally more numerous in the fertilized pond than the unfertilized pond (Tables 10, 11, and 12).

The more rapid rate of growth of fry in the fertilized pond apparently ceased around 26 July (Figs. 1 and 2, Tables 1 and 3). A drop in the fertility of the water as reflected in the phytoplankton and rotifer populations (Fig. 3, Table 10), and a large decrease in the midge larva population (Table 12) also occurred by this date. This drop in the chironomid population was also noted in a drop in midge numbers in the stomach contents (Tables 8 and 9) and a lessening in the midge volume in stomach samples of fish from both ponds

(Tables 5 and 6). The fry in the fed pond responded by utilizing greater amounts of feed (Table 6), and fry in Pond No. 5 began taking greater amounts of crustaceans (Tables 5 and 8). The effect of a drop in density of the chironomid population on fish growth was reflected in a decreased rate of gain of fish in Pond No. 5 (Tables 1 and 3, and Figs. 1 and 2). Cessation in rate of gain of total stomach content volume, chironomid volume of the stomach contents (Table 5), and numbers of chironomid larvae found in the stomach samples (Table 8) was also seen in fry from the fertilized pond.

A slight decrease in the volumetric (Table 6) and numerical (Table 9) importance of chironomids to the fed fry also took place on 26 July when the chironomid population declined in Pond No. 6 (Table 12). This decline in the importance of midges in the diet had begun with the acceptance of supplemental feed three weeks earlier (Table 6). The effect of the drop in the chironomid population was not shown in the growth of the fed fry (Figs. 1 and 2, Tables 1 and 3) because of this important additional food source.

The volumetric decrease in importance of midge larvae was constant throughout the summer in Pond No. 6 (Table 6) with the exception of 2 August when rain apparently decreased the availability of the supplemental feed, and a shift to chironomids in the diet occurred. The drop in volume of supplemental feed in the stomach samples on 2 August was also seen in the total stomach volume (Table 6) where a drastic drop occurred on this date.

Large seasonal variation in chironomid larva numbers was described by Anderson and Hooper (1956). Predation by aquatic vertebrates, emergence of adults, and changes in the bottom matter can play a role in these midge population changes (Hilsenhoff, 1967; Buckley and Sublette, 1964). A decline in fertility of the water as seen in the algae and rotifer populations (Table 10, Fig. 3) may account for the chironomid population decline in Pond No. 5. In Pond No. 6, however, an algae bloom was starting on 26 July (Fig. 4, Table 11), and would seem to contradict the assumption that lack of nutrients was the cause for the drop in the midge population. Fish predation, emergence of adults, and the sudden introduction of sand to the bottom sediments by rain on days prior to the drop in population may have all contributed to the decline.

The fry in the unfertilized pond first started taking supplemental feed on 9 July, and gained steadily with no periods of little or no gain as noted in Pond No. 5 (Figs. 1 and 2, Tables 1 and 3). The steady rate of gain shown by fry in Pond No. 6 would indicate that supplemental and natural food was available in amounts large enough for good growth both before and after the acceptance of supplemental feed. The inability of the natural organisms to maintain good growth in the fertilized pond after 26 July was seen in the slow rate of growth prior to feeding on 22 August (Figs. 1 and 2, Tables 1 and 3). The immediate acceptance of feed by fry in Pond No. 5 when feeding was initiated on 22 August indicated young channel catfish required no period of learning to become accustomed to supplemental feed. This immediate acceptance would also indicate that the length of time prior to taking feed by fry in Pond No. 6 was not due to learning but to some other reason such as the ability of natural organisms to sustain the fry. Possibly when the natural food became less able to support the fry, a shift in feeding habits to supplemental feed occurred. Another indication that learning was not involved in the time feed was first taken was the previous experience of the fry with supplemental feeding. For three days after hatching and prior to stocking in Ponds Nos. 5 and 6, the fry were seen to feed on powdered buttermilk when offered at the Kansas Forestry, Fish and Game Commission hatchery at Pratt.

The natural food of young channel catfish fry was small aquatic insects, primarily chironomid larvae, but later they have been observed to be omnivorous, and eat anything that was abundant in direct proportion to its availability (Darnell, 1958; Turner, 1966). This would explain the preference of fry in Pond No. 6 for midge larvae prior to acceptance of supplemental feed, and the immediate acceptance of feed by the fish in Pond No. 5.

The response of fish to supplemental feeding in the fertilized pond was seen in an increased rate of growth (Tables 1 and 3, Figs. 1 and 2) as well as the presence of feed in the stomachs and increased stomach content volume (Table 5). The fish in Pond No. 5 never became as large as fish in Pond No. 6 even after the acceptance of feed by the fish in the fertilized pond. The rate of gain, however, was apparently equal to that of fish in Pond No. 6 after the change in diet. This ability to go from a period of slow growth or lack of growth to fairly rapid gain when supplemental feed was added to the diet has also been noticed in larger channel catfish (Tiemeier and Elder, 1960). As

As in the present study, they indicated food availability was a limiting factor in growth.

Even though feed was added to the diet of the fry in the fertilized pond late in the study, the mean weight, pounds of fish, pounds per acre, fish per acre, number of fish, and number of fish harvested per pound of fry stocked were all higher in the fed pond based on the results of the final seining on 28 September (Table 15). The superiority of continuous supplemental feeding to fertilization was also noticed by Crance and McBay (1966). If the assumption that equal numbers of fry were stocked was correct, the greater number of fry in the fed pond would also indicate better survival.

Because initial growth was better in the fertilized pond, and because of the rapid acceptance of feed when offered, it would appear that a combination of feeding and fertilization might produce better growth in fry than either method alone. This combination would not necessarily have to commence simultaneously. The fertilization would be initiated immediately after stocking, and the supplemental feeding program could be started after the fry were about one month old.

SUMMARY

1. Fertilizing a pond with 46% triple superphosphate resulted in higher initial blooms of phytoplankton and zooplankton than were obtained in an unfertilized pond.

2. Chironomid larvae were more abundant in the fertilized pond than in the unfertilized pond from the date the first bottom sample was taken (25 June) until 2 August.

3. Benthic organisms, especially midge larvae, were the most important components of the natural diet of the fry.

4. Channel catfish were larger in the fertilized pond than in the continually fed pond from the first sampling date (21 June) until 6 August.

5. Rate of growth of fry in the fertilized pond was less after 26 July probably because a drastic drop in the midge larva population of the pond occurred on this date. A drop in the midge larva population of the unfertilized but fed pond also was noticed on 26 July, but due to prior acceptance of supplemental feed, no effects of this decline were seen in the growth of the fry.

6. Channel catfish fry in the continually fed pond did not accept discernible amounts of supplemental feed before they were about 3 weeks old (9 July) and obtained a weight of approximately one gram.

7. Channel catfish fry in the fertilized pond immediately accepted feed when it was offered to them for the first time at an age of about 2 months. This indicated that an extensive learning process was not necessary for the fry to utilize supplemental feed. A minimum size or age, or a lack of sufficient natural food was probably the determining factor in acceptance of supplemental feed.

8. Growth rate of fry in the fertilized pond after accepting supplemental feed was comparable to that of fry in the continually fed pond. Average size of fry in the fertilized pond, however, was never as great as that of fry in the continually fed pond after 6 August.

9. Greater production was achieved with continual supplemental feeding than fertilization with supplemental feed introduced late in the season.

10. On the basis of growth data, it was hypothesized that better and more economical growth would have been obtained if ponds had been fertilized at the outset of the experiment and feeding initiated after about three weeks had elapsed. This probably would have avoided the slow rate of gain seen in the fertilized pond after 26 July and prior to supplemental feeding on 22 August. Furthermore, the feed given fry in the unfertilized pond before acceptance of supplemental feed on 9 July would not have been wasted.

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GROWTH AND FOOD HABITS OF SUPPLEMENTALLY FED AND UNFED YOUNG-OF-THE-YEAR CHANNEL CATFISH (ICTALURUS PUNCTATUS) HELD IN TWO PLASTIC-LINED PONDS

by

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AN ABSTRACT OF A MASTER'S THESIS

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To study the growth and food habits of channel catfish fry, equal weights of fry were placed in each of two plastic-lined ponds. One pond was fertilized with 46% triple superphosphate and received no supplemental feed until late in the study. The other pond was not fertilized, but the fry were fed twice daily throughout the study.

Growth rate of fry in the fertilized pond was greater for the first month of the study than rate of growth exhibited by fry in the continually fed pond. Plankton tows and bottom samples revealed much higher plankton and midge larva populations in the fertilized pond than the unfertilized pond for the first month.

A drop in the population of important food organisms in both ponds produced a decline in rate of growth of fish in the fertilized pond. Supplemental feeding in the unfertilized pond prevented growth of fry in this pond from being adversely affected by this drop in the population of natural food organisms.

Stomach sample analysis of fry from both ponds showed chironomid larvae and zooplankton, especially Bosmina, Alona, and Cyclops, were important constituents of natural foods. Acceptance of supplemental feed by fry in the fed pond occurred three weeks after stocking when fry averaged about 1 gram. Supplemental feed was first presented to fry in the fertilized pond approximately 9 weeks after stocking. For about one month prior to the introduction of supplemental feed to these fry, no significant growth had been noted. Acceptance of feed by fry in the fertilized pond was immediate, and a response was shown by an increase in growth rate. Utilization of supplemental feed by fish in both ponds produced a drastic drop in volumetric importance of natural food organisms. Total production of fish for the growing season was higher in the continually fed pond than in the fertilized pond.